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ADVISORY GROUP FOR AEROSPACE RESEARCH & DEVELOPMENT
7 RUE ANCELLE 92200 NEUILLY SUR SEINE FRANCE

AGARD ADVISORY REPORT 300

Technical Evaluation Report on the Flight Mechanics Panel Symposium on Progress in Military Airlift

(Les Progrès Réalisés dans le Domaine du Transport Aérien Militaire)

NORTH ATLANTIC TREATY ORGANIZATION

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Technical Evaluation Report on the Flight Mechanics Panel Symposium on

Progress in Military Airlift

(Les Progrès Réalisés dans le Domaine du Transport Aérien Militaire)

by

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This Advisory Report was prepared at the request of the Flight Mechanics Panel of AGARD.

North Atlantic Treaty Organization
Organisation du Traité de l'Atlantique Nord

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According to its Charter, the mission of AGARD is to bring together the leading personalities of the NATO nations in the fields of science and technology relating to aerospace for the following purposes:

— Recommending effective ways for the member nations to use their research and development capabilities for the common benefit of the NATO community;

— Providing scientific and technical advice and assistance to the Military Committee in the field of aerospace research and development (with particular regard to its military application);

— Continuously stimulating advances in the aerospace sciences relevant to strengthening the common defence posture;

— Improving the co-operation among member nations in aerospace research and development;

— Exchange of scientific and technical information;

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Preface

Military transport aircraft and helicopters will continue to be of increasing importance in future military operations. Due to economic constraints, military transport aircraft technology has not received the same level of attention that has been directed, for example, to combat aircraft. In-service fleets of transport aircraft are also becoming physically old and technically outdated, and are less and less capable of fulfilling the more demanding mission requirements.

It was therefore considered important and timely to review this area and assess:

— The present and perceived future military roles and requirements for airlift;

— The developments in technology necessary to fulfill the requirements;

— The extent to which technology developed for civil applications can enhance the capabilities of military transport aircraft and helicopters;

— The kind of technology that can bring real cost reductions; and

It was also considered important to review the current and future development programmes in this field, and assess to what extent they embody the new technologies.

A symposium sponsored by the Flight Mechanics Panel of AGARD entitled 'Progress in Military Airlift' was seen as the best way of examining some of these aspects. The Symposium included sessions on operational experience and requirements; cockpit design and aircrew performance; specific technologies such as fuel, powerplant and aerodynamic design; and a review of current and new programmes.

This Technical Evaluation Report evaluates the presentations and discussions in each session, makes appropriate comments, draws relevant conclusions and makes recommendations for future activities in this area.

Préface

Il y a tout lieu de croire que l'importance croissante qui est accordée aux aéronefs et aux hélicoptères de transport militaires sera maintenue lors des opérations militaires futures. Jusqu'ici, en raison des constraintes économiques, les technologies entrant dans la construction des aéronefs de transport militaires n'ont pas suscité le même intérêt que celles employées pour les avions de combat par exemple.

Les flottes d'avions de transport qui sont en service à l'heure actuelle sont vieillissantes, techniquement démodées et de moins en moins aptes à répondre aux exigences de certaines missions difficiles.

Il est donc été considéré comme nécessaire et opportun d'examiner l'état actuel des connaissances dans ce domaine, ainsi que d'évaluer:

- le rôle militaire présent et futur et les spécifications du transport aérien militaire.
- les développements dans les techniques nécessaires pour répondre à ces spécifications.
- la mesure dans laquelle les technologies développées pour des applications civiles peuvent servir à augmenter les capacités des avions et hélicoptères de transport militaire.
- les technologies susceptibles d'amener une véritable réduction des coûts.

Il a également été considéré comme important de faire le point des programmes de développement actuels et projetés dans ce domaine, et d'estimer leur contribution potentielle pour des technologies nouvelles.

Le Panel AGARD de la Mécanique du Vol, a décidé que l'organisation d'un symposium intitulé "Les Progrès réalisés dans le domaine du transport aérien militaire" fut l'une des meilleures voies pour examiner certaines de ces questions.

Le symposium comprit des sessions sur les spécifications et l'expérience opérationnelles, la conception du poste de pilotage et les performances des équipages, les technologies employées dans des domaines spécifiques tels que les combustibles, les propulseurs et la conception aérodynamique, ainsi qu'un résumé des programmes en cours et prévus.

Ce Rapport d'Evaluation Technique évalue les présentations et les discussions qui ont eu lieu lors de chaque session. Il fournit des commentaires appropriés, et tire les conclusions qui s'imposent et soumet des recommandations concernant des activités futures dans ce domaine.

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1/ Introduction.

For the first time in its 38 year-life, the AGARD Flight Mechanics Panel devoted a full Symposium to Airlift.

Of course, in other symposia, organized by the FMP or even by other AGARD Panels, some parts could more or less apply to transport aircraft. (For example, appendix 1 lists the lectures that could be targeted to airlift in the last decade of FMP Symposia).

The rarity of this event is a kind of a confirmation of the secondary role in which transport aircraft were considered, compared with fighter aircraft,- something like cavalry and freight-wagons in the ancient times.

A more important manifestation of this disfavour was that Airlift used to be ignored in budget priority in nearly all countries (except perhaps in the USSR!), which resulted in the fact, several times mentioned during this symposium, that no new airlifter has been put into operation during the last twenty years, and even, speaking of a "tactical" airlifter, during the last thirty years.

However many conflicts in the last forty years revealed the growing importance of airlift, the last and most striking example having occured just after this symposium.

Recently, taking into account these various experiences and the progressive phasing out of the existing aircraft, several countries started thinking about what a new tactical airlifter would look like, which made this symposium come in the right time to benefit from these studies. With the addition of the wave of new technologies, many of them having been already developed for civil airplanes, ample matter was available for its programme.

Let us also recall that the Symposium had to be responsive, when relevant, to the Technology Study Proposal on "Flight Deck Configuration and Systems Requirements for the NATO Future Large Aircraft" (TSP 1/87). However, the TPC decided that, for a symposium, it would be more appropriate to enlarge the scope, to cover the full range of advanced technologies applicable to a new generation of military transport aircraft.

This resulted in the overall programme as exposed in the Pilot Paper No 166 which addressed the questions:

"a/ What are the present and perceived future military roles and requirements for airlift?

b/ What are the developments in technology necessary to fulfill the requirements?

c/ To what extent can technology developed for civil applications enhance the capabilities of military transport aircraft and helicopters?

d/ What kind of technology can bring real cost reductions?

e/ What are the current and future development programmes in this field, and to what extent do they embody the new technologies?"

In answer to these questions, the 29 lectures which were selected by the TPC for the Symposium (one of which was canceled) endeavoured to show:

_ how evolution in the World situation and related potential conflicts would bring airlift to the front of the stage,

_ how technological progress will improve the overall efficiency of airlift,

_ why selfsufficiency will be one of the main requirements,

_ but also how, pending a new generation of tactical airlifters, efforts had to be deployed to extend the service life of existing transport airplanes far beyond initial expectancy.

2/ Technical evaluation.

Appendix 2 gives the list of all lectures with a short summary for each of them.

2. 0. Keynote address:

Group Captain Keith CHAPMAN's former position in NATO Head Quarters gave him both a good knowledge of the strategic importance of Airlift and an opportunity to express non official personal views.

On a general political point of view, he was not in favour of reducing armaments for the mere reason that the threat from Eastern Europe is decreasing: other conflicts are likely to arise elsewhere in the World, he argued.... in a somewhat prophetic manner at that time!

Coming to Airlift, he stressed the contradiction between this present trend for armament reduction and the need to renew the aging military transport fleets. He advocated exempting airlift from this reduction at a time when it appears to take a growing importance in the forseen types of conflicts, as was emphasized by several examples in the last 20 years (and in a most striking one which occured just several weeks after this Symposium).

This very lively lecture pointed out the importance of Airlift in modern warfare and was a perfect tune in for the Symposium.

2. 1. SESSION I. Operational Experience and Requirements:

This session was composed of five lectures. It was aimed at showing how military Head Quarters in various countries are conceiving their Airlift strategies for the years to come. Approaches were varied, giving more or less emphasis to experience gained in past conflicts or to scenarios chosen to comply with a global strategy and to cover the most probable types of operations (for example, both U.S. lecturers, on airplanes and on helicopters, used the same set of 3 scenarios).

In the case of international cooperation, the requirements of countries having different needs or strategy concepts increases the difficulty of trade-offs.

Though it was commonly agreed that Airlift would use combined fleets, with heavy transport aircraft,- and civil airplanes for limited use -, the need for an "Advanced Tactical Airlifter" remained.

In trying to summarize the main requirements, most of the analyses made the cargo hold capacity in size and weight emerge as number one: it was pointed out by all lecturers, perhaps following passed desappointing experiences. All authors stressed the need to give thorough attention to the inventory of present and foreseen weapons, vehicles and equipments to be carried, keeping in mind their constant tendancy to grow in size and weight. An additional wish was expressed for easy adaptation to other duties: air-refueling, medical uses, command aircraft, etc.

If complying with this requirement is, with some simplification, rather straightforward, other important ones are calling in many and various characteristics and features of the project, which will interfere with and impose trade-offs.

The most important are:

_ Quick delivery.

_ Self sufficiency.

_ Survivability.

_ Coordination with other engaged units.

Quick delivery:

. Speed is not the only parameter involved, but also,
. range to prevent intermediate stops and
. capability of delivery as close as possible to the battlefield, to avoid multiple handlings and use of surface transport means.

Thus, many aspects are involved:

_ Efficient aerodynamics (including high lift devices),

_ fuel capacity and in flight refueling,

_ Low consumption powerplants,

_ Sophisticated and discrete navigation systems, including terrain following and autonomous all-weather landing systems,

_ Low level airdropping,

_ Rugged landing gear for use of short unprepared strips,

_ Quick cargo handling,

_ etc

Self sufficiency:

Which means operation :

_ without any guidance from the ground in the destination area,

_ without any GPU or other support means, whatever the climatic conditions,

_ without any ground handling means,

_ etc.

Survivability:

for which the main contributors are:

_ Discretion which calls again in adapted aerodynamics and powerplants as well as in terrain following capabilities,

_ Short time on the ground, which needs good ground manoeuverability and rapid cargo handling means,

_ Rugged structure and control systems,

Coordination with other engaged units:

The navigation/communication systems of the airlift fleet must be fully integrated in the C^3I system, so that, in particular, load delivery is consistent with the real time situation on the battlefield.

This description does not pretend to be an exhaustive survey of all points which were exposed and have to be accounted for, but rather helps showing how the authors, giving more or less emphasis to these various parameters, arrived at different solutions, found best adapted to their particular needs.

Comments: Peacetime:

It is fully understandable that all scenarios taken into consideration were war or at least conflict situations. However it must be remembered that airlifters will spend most of their lives in peacetime and, contrary to fighter aircraft, will be usefully operated during all that time.

Very little was said on this (only one author mentioned it explicitely), though it can be considered that everything dealing with efficiency, life cycle cost, etc, is of high importance in peacetime.

However, in the past, several airplane fleets had to have their airframes reinforced and requalified to extend their lives, because their peacetime activities had been underestimated; in addition, their equipments and instruments became completely obsolete and had to be replaced, because of their unexpected longer lives.

It would have been of interest to hear how this will be taken into consideration in the future, in routine operation as well as in case of catastrophic situations. Everybody can remember that tactical transport airplanes were of great help in such disasters as earthquakes, floods, starvation situations, etc, thanks to their ability to operate to and from unprepared fields and without any local support. Alas, the same mishaps are still likely to occur and lessons should be drawn from the past experience to help saving lives in peacetime as well as in wartime. This could be an additional reason not to reduce the airlifter fleets, in the above mentioned present trend.

2. 2. SESSION. II Cockpit Design and Aircrew Performance:

Among the improvements on aircraft in the recent years, the most spectacular is the complete transformation of the flight deck, with both visible and concealed changes. This crew/ airplane interface modification has resulted in an evolution of the crew tasks and, as a consequence, of its behaviour. Four lectures dealt with new cockpit designs, while two others were devoted to more physiological aspects: fatigue and protection against toxic gases.

Cockpit Design:

Of the four papers:

. one dealt with general considerations on new-design cockpits and attention to be given to related crew/ flight deck problems,

. one described a new cockpit design capable to be retrofitted on existing aircraft,

. one described how flight decks for existing or future military transport aircraft could be derived from recent civil airplane cockpits,

. one described the process of developing the flight deck of an airlifter, during the development of the aircraft itself, with the help of a set of successive specific simulators. It showed how the basic concept of crew/ aircraft interface underwent some changes along this process.

It should be emphasized that, for the old aircraft whose structures, mechanical parts and engines are capable of extended life, changing equipments, with their frontpieces in the cockpit, is made mandatory because the original analog-lype instruments are now completely obsolete and out of production, so that neither repairs are possible nor spares are available. In addition the new equipments are much more reliable and capable of extended fonctions.

In all cases a tight filiation with modern civil airplanes is obvious, rather than with combat aircraft, because of closer types of operation.

However, while the projects presented take full benefit from the glass cockpits now in use on civil airplanes, some of their features are advancing one step more forwards in proposing further improvements or new concepts which can be more easily tested on military aircraft. The most prominent examples are:

_ Liquid crystal display (LCD), the flat panel of which needs little room behind the instrument panel, compared with the cathode ray tubes (CRT). In addition, this equipment is expected to be much more reliable, because of its progressive failure mode.

_ Head-up display (HUD) used as primary flight display, which prevents the pilot from continually looking from outside to inside the cockpit and back. In addition this leaves more room on the instrument panel for navigation and systems displays.

_ New navigation techniques in warfare environment, with protection means against hostile actions. Some of these techniques could later evolve towards civil applications (navigation systems, ground or collision avoidance, etc.).

_ Extended mission management, with terrain following assistance and automatic guidance in adverse conditions (weather and hostile) for airdropping and assault landing.

<u>The Crew/ cockpit interface problem:</u>

One particular concern appeared in all presentations and in many questions from the floor: the pilot behaviour. This concern arose in part from reported difficulties encountered when the Airbus A 320, the Fokker F 100 and the Boeing B 747-400 entered into operation, in spite of the fact that their systems were developed in close cooperation with airline pilots. A central point in the discussion was the comparison between the onboard software stiffness and the flexibility and capacity of initiative of the pilot.

Though the problem is considered under control on the civil side, it still raised questions on the difficulty to "keep the pilot in the loop" in all aspects: aircraft control, alertness, quick perception of abnormal situations, etc.

The papers addressed this question in different ways (controling or monitoring?) but the objective was always the same: avoid loss of attention of the crew.

This subject leads naturally to the fifth paper on fatigue countermeasures. Though it was centered on circadian rythms and jet lag, it also examined the ways to maintain the pilot alertness and thus the subject was not very far from the glass cockpit interface problem.

The last paper dealt with a very specific physiological problem: a device to survive a gas threat. The only thin connection with the other papers was the need for the mask to comply with the cockpit duty of the crew, but this is obviously a necessary requirement for an airlifter to operate in high-threat conditions.

<u>Comments:</u>

Once again, operations in peacetime and in wartime can be opposed.

In the peacetime, a tactical transport will operate in the same environment as civil airplanes and the ambient situation in the cockpit is the same. On the contrary, in wartime the tactical airlifter will have to fly in a hostile environment, which could mean that:

_ the crew has to make instant changes in the flight plan, hopefully with the help of an easy reprogrammable FMS;

_ the cockpit should survive heavy losses in information channels and still provide the basic flight parameters.

This will probably be the subject of specific studies in the coming years.

2. 3. SESSION III. Specific Technologies:

This session gathered all papers on technologies, apart from "cockpit design" (dealt with in session II). Therefore it had no real structure and was composed of individual, non connected lectures. However, two papers, N° 17 and 19, made a survey of the new technologies of interest and described some projects with the resulting improvements in performance and in operation flexibility to be expected. Both papers can be considered as direct and logical follow-up of the session I.

Another paper on a Rear Vision Device (N° 18) did not only describe the device but exposed how rear vision permitted to develop defence tactics against air to air attacks from the rear. It was psychologically positive for airlift crews in showing that transport airplanes are not mere easy game for fighter aircraft.

Coming to technology descriptive papers, one must notice that they were limited to powerplants and aerodynamics.

Paper 13, on a "Fuel with Higher Energy density" related the development which is presently in progress in Canada on this subject, with a secondary goal, improved characteristics in cold weather. The obvious aim is to extend the range of tank volume limited aircraft which are not weight or fatigue limited. If the research study is successfull, as it is likely, the selected fuel could have civil applications as well.

Paper 14 was a survey of the various types of powerplants that could be fitted on a large transport airplane. In the iterative cycle of project definition, the powerplant is most important. Speaking of optimization, the leading parameter for a military engine is a high power to weight ratio, whereas, for a civil engine, low SFC and reliability are more important. However, comparison between the various solutions is biased by the fact that civil engines are available, "mass" produced and log millions of flight hours a year. Not only does this reduce prices but it also allows rapid improvement in SFC, reliability and thrust, thence in power to weight ratio as well. Then a choice is not straightforward between projects equipped with either military dedicated or civil derived engines.

Paper 15 spoke again of powerplant but focused on its adaptation to the wing. Comparing different versions of high by-pass ratio engines, in addition to the usual perfomance parameters, it took also into account installation simplicity, radar discretion and maintainance easy access. A "Direct Drive Aft Contrafan" was favoured by the author but interested airframe manufacturers have now to make their own choice.

Paper 16 described a new wing concept liable to largely improve powered-lift efficiency both at high and low speeds. This paper, speaking mainly of aerodynamics studies, computations and windtunnel tests, could have rather been an FDP contribution. Though examples of airplane projects were given, the study did not seem to be advanced enough to address such aspects as flight dynamics, engine out operation, etc.

Comments:

It must be admitted that among the various technology subjects presented, though all are of interest and relevant to the tactical transport, very little is "specific" to this subject. Apart from the rear vision device, all papers can more or less apply to other types of large aircraft. On the contrary, one must regret that the TPC was not offered papers on more specific techniques such as:

- precision automatic and autonomous landing systems,
- rough terrain landing gear,
- on board quick loading and unloading devices,
- low altitude airdropping techniques and devices,
- etc.

One must confess that such devices or systems are not usually developed on their own but as part of an aircraft project.

The present status of future tactical airlifter programmes tends to favour general concepts and configurations rather than the above mentioned subjects. In a more advanced phase of development, such papers would probably have been available.

2. 4. SESSION IV. Current and New Programmes:

This session was composed of nine descriptive lectures. It covered a wide range, from potential projects to programmes in their development phases, and included airplane types already in operation and modified for rejuvenation or for new purposes.

Three papers dealt with existing aircraft.

The most remote in the R&D progress was the HTTB programme (paper 23), using the C-130 platform. Though it used the same a/c as the RAMTIP programme (see paper 7), it was completely unrelated. The Hercules is used as a testbed on which advanced research can be conducted in high-lift aerodynamics, flight controls, powerplant, avionics, etc... A very sophisticated and powerful data aquisition system was devised to conduct these tests.

This programme is original in that equipment Suppliers (60) are invited to participate on a cost sharing base.

Though no reference to production Hercules improvements was made, it was several times mentioned that modifications had been very easy to introduce on the basic aircraft.

The paper 22 described the C-160 Transall Life Time Extension programme now in progress in the German Air Force.

In addition to an updating of systems and avionics, this programme includes a complete evaluation of the structural and mechanical condition, through inspections of sample aircraft, for further repair or reinforcement of all the airplanes of the fleet. This very comprehensive programme spreads over 15 years for the whole fleet and will result in a life extention of 20 years with highly modernized avionics, allowing the Luftwaffe to wait for the next European airlifter programme.

The paper 21 " Problems in Converting Civil Aircraft to the Military Tanker Role" was a complement to paper 6 in session I.

After having exposed the requirements, it detailed the advantages of the solution as well as its drawbacks foreseen or revealed in operation. Experience gained will benefit a further study for a future dedicated tanker programme.

Paper 20 was a general paper. It showed that the many commuter programmes launched in the last twenty years resulted in extensive improvements in performances and systems. During the same period, no tactical airlifter programme was launched, so that a new medium military transport would benefit of all these progresses against a now operating aircraft.

The last five lectures (24 to 29, with 26 cancelled) described new projects or programmes in a more or less advanced phase.

Paper 25 dealt with the purpose of a group of European Countries to develop a tactical airlifter in cooperation. The requirements of the different Countries are being compared and trade-offs are being weighed. For the time being, the overall configuration has not yet been chosen, neither have maximum payload and range, powerplant type and number, etc, been defined. However there is a good prospect for this programme to be launched, with a production expectation of at least 1000 aircraft.

On the contrary, the C-17 programme (paper 24) is now in a well advanced phase of development, since the first prototype aircraft will fly in 1991. Though ranking as a strategic airlifter, it features some characteritics of a tactical aircraft (ex: use of short semi-prepared airfields). Its cargo hold can accomodate large vehicles and is equipped with an efficient load system. The glass cockpit claims to advance one step further than equivalent civil airplanes, with the HUD being used as primary flight instrument (see

The EH-101 helicopter, a British-Italian cooperative programme, is still more advanced, since it has now been flight tested for more than two years.

This aircraft is very versatile and is claimed to meet needs as varied as: battlefield tactical helicopter, naval ASW vehicle and civil or utility helicopter.

Strong emphasis was put on reliability and survivability, both for the structure and for the propulsion system (powerplant and rotor assembly). The advanced design of the rotor blades gives it brilliant performances.

The two remaining lectures, N° 27 and 28 dealt with tilt-rotor aircraft.

They opposed each other by some aspects:

_ the V-22 is a military project at the end of its development and put at idle, pending a decision from the US Government to launch the programme . The concept has now been fully demonstrated and civil projects could later stem from it.

_ the EUROFAR project will be a cooperative civil programme, but for the time being it is in a feasibility study phase. Further possible military applications were described.

3/ Conclusions.

At last a symposium on Airlift was organized and it interested about 150 people.

This symposium emphasized the relatively poor situation of the tactical Airlift in the NATO Countries. Fleets are old, in some aspects obsolete, and have to be rejuvenated, pending the arrival of new aircraft for which programmes have not yet been launched but are likely to start in the coming years.

This perspective gave the opportunity to several Lecturers to develop strategic concepts for tactical airlift and to others to describe potential projects for future programmes.

In the last 20 years, there has been a lot of improvements in aeronautics: lighter airframes, powerplants with better power to weight ratio, lower fuel consumption and enhanced reliability. In systems, the numerical techniques have even brought a more radical transformation and given birth to the "glass cockpit". All these progresses will benefit a new airlifter, as much as any other type of aircraft. Compared to the previous generation, it will result in a big step upwards in performance, operability and reliability.

It must be emphasized that the full and interesting session II: "Cockpit Design and Aircrew Performance" was an adequate response to the TSP 1/87: "Flight Deck Configuration and Systems Requirements for the NATO Future Large Aircraft".

On the contrary, very little was devoted to very specific techniques of tactical airlifters (airdropping, rough landing, ground handling, etc).

Nevertheless, apart from this particular aspect, the Symposium gavegave a complete overview on:

_ the present airlift status and perspectives in the context of the World situation,

_ the resulting requirements for the soon expected programmes, which should be launched in a short delay to prevent from any gap with the phasing out present fleets,

_ the modern techniques which will benefit these new aircraft and make them considerably more efficient than the preceeding generation.

4/ Recommendations.

The first recommendation echoes a statement from the Keynote Address Author, confirmed all along this Symposium: it is now urgent that one or two tactical airlifter programmes are launched in the NATO Countries for two main reasons:

_ present fleets will soon be completely phased out;

_ future foreseeable types of conflicts are likely to require an increased airlift contribution.

The second recommendation is for the FMP not to wait another 38 years to organize a second symposium on Airlift: there is a good prospect for one or two tactical airlifter programmes to be launched within a few years and a second meeting would be of interest when their development phases are advanced enough.

On the technical point of view, the most important recommendations are for:

_ the cargohold shape and sizes to be thoroughly matched to all known present and future loads to be carried;

_ a range as long as possible and air-refuelling capability;

_ extensive studies and experiments, possibly in flight, on the crew/cockpit interface problems, taking into account the wartime flight conditions;

_ consideration to be given to peacetime operation, which will hopefully be by far the largest part of the complete life cycle of a new airlifter.

APPENDIX I

PAPERS APPLICABLE TO AIRLIFT IN FMP SYMPOSIA DURING THE 80'S

Symp.		Symp. title
	Paper N°	Paper title
Spring 80		**Design to Cost and Life Cycle Cost.**
	14	A New Method for Estimating Transport Aircraf Direct Operating Costs.
	15	Le "Design to Cost" Appliqué à l'Hélicoptère AS 350.
	20	Impact of Maitainability on Life Cycle Costs.
Fall 80		**Subsystem Testing and Flight Test Instrumentation.**
	1	Tactical Navigation System Testing.
	13	Advances in Landing Gear Systems.
	25	A Method for Measuring Take-off and Landing Performance of aircraft, using an Inertial Sensing System.
Spring 81		**The Impact of Military Applications on Rotorcraft and V/STOL Aircraft**
Spring 82		**Criteria for Handling Qualities of Military Aircraft.**
	7	Handling Qualities of Transports with Advanced Flight Control Systems.
	11	The Status of Military Helicopter Handling Qualities Criteria.
Fall 82		**Ground/ Flight Test Techniques and Correlation.**
	6	Experimental Investigations of Transport Aircraft Low Speed Engine Interference Effects and Flight Test Correlation.
Spring 83		**Flight Mechanics and System Design Lessons from Operational Experience.**
	5	Incident Reporting - Its Role in Aviation Safety and the Aquisition of Human Error Data.
	12	Influence of Windshear on Flight Safety.
	14	Army Helicopter Crashworthiness.
	20	L'Interface Homme- Machine dans les Avions Commerciaux de la Nouvelle Génération.
	22	Modern Flight Instrument Displays as a Major Military Aviation Flight Safety Weakness.
Spring 84		**Flight Test Techniques.**
	4	Determination of Performance and Stability Characteristics from Dynamic Manoeuvres with a Transport Aircraft Using Parameter Identification Techniques.
	9	The Handling and Performance Trials Needed to Clear an Aircraft to Act as a Reciever During Air-to-Air Refuelling.
	12	Assessing Pilot Workload in Flight.

Fall 84		**Active Control Systems-Review, Evaluation and Projections.**
	14	Demonstration of Relaxed Static Stability on a Commercial Transport.
	15	Realisation of Relaxed Static Stability on a Commercial Transport.
	18	Active Control Landing Gear for Ground Load Alleviation.
	21	How to Handle Failures in Advanced Flight Control Systems of Future Transport Aircraft.
Spring 85		**Unsteady Aerodynamics - Fundamentals and Applications to Aircraft Dynamics.**
	35	Gust Alleviation on a Transport Airplane.
Fall 85		**Flight Simulation.**
	13	Simulation des Commandes de Vol Electriques au Centre d'Essais en Vol Français (CEV) pour les Avions de Transport Civils.
Fall 86		**Rotorcraft Design for Operations.**
Spring 87		**Flight Vehicle Development Time and Cost Reduction.**
Fall 87		**The Man-Machine Interface in a Tactical Aircraft Design and Combat Automation.**
	4	Expert System for Low Level Tactical Mission Preparation.
	10	Advances in Workload Measurement for Cockpit Design Evaluation
	29	Matching Crew System Specifications.
Fall 88		**Flight Test Techniques.**
Spring 89		**Flight in Adverse Environmental Conditions.**

<u>NOTA</u>

If a good part of a whole symposium was found relevant to Airlifters, no detailed list of titles was given.

APPENDIX II

LIST OF LECTURES
with brief summary

KEYNOTE ADDRESS.

1. A NATO Perspective on Airlift Operations in a Changing Politico-military Environment.
   Group Captain Keith CHAPMAN, NATO H. Q.
   The World situation is rapidly changing and Governments are contemplating (too quickly?) armament reductions. This should not hit Airlift which will gain more and more importance in the possible future conflicts.

SESSION I. Operational Experience and Requirements.

2. The Study Approach and Perceived Needs for an Advanced Theater Transport.
   V. VUKMIR, USAF/ Wright Patterson AFB, US.
   Three likely conflict scenarios help define a future tactical airlifter. Main characteristics: cargohold sizes, rapidity, self sufficiency.

3. The US Army Next Generation Transport Rotorcraft.
   C. JARAN, Sikorsky, US.
   The same three scenarios are used to define the future helicopter. In a rather classical formula, hopes are put in materials, modern engines and rotors.

4. General Configuration Aspects on Airlifter Design.
   J. L. LOPEZ DIEZ, J. R. HERRERA IBORRA, J. L. ASENJO TORNELL, CASA, SP.
   Experience in small transport aircraft is used to contribute to the definition of a European airlifter. Difficulties arising from international cooperation are quoted.

5. Experience Gained from recent French Airforce Operations
   A. BEVILLARD, J. de LISI, French Air Force, FR.
   French AF Transall revealed very efficient in operations. However, two or three insufficient features should be taken into account for a future programme.

6. Recent Improvements to the RAF Transport Force.
   D. MACINTOSH, D. FITZGERALD-LOMBARD, Joint Air Transport Establishment, UK.
   To replace a rapidly phasing out fleet, civil airplanes were converted into air-refueling transport a/c. Advantages and drawbacks. Experience gained.

SESSION II. Cockpit Design and Aircrew Performance.

7. C-130 Electronic Cockpit - Reliability and maitainability technology Insertion Program (RAMTIP).
   R. L. RUSSELL, USAF/MAC, US.
   A project to rejuvenate the C-130 cockpit. Advantages of the LCD in the instrument-panel arrangement. A calendar for retrofit is given.

8. Apport des nouvelles technologies dans les cockpits des avions futurs de transport militaire.
   G. MITONNEAU, J. BORREL, D. DUTURC, Aérospatiale, FR.
   The experience gained on the Airbus glass cockpits can be used to retrofit the French AF Transall and for the future European Airlifter.

9. Advanced Technology Application in the Flight Deck Design for Military Transport Aircraft.
   A. LAPASTINA, V. AFELTRA, Aeritalia, IT.
   A general study on advanced cockpits, which emphasizes the crew/cockpit interface problem.

10. C-17 Piloted Cockpit Testing.
    B. HECKATHORN, Wright-Patterson AFB, US.
    How the C-17 cockpit was developed through successive simulators. Evolution of the cockpit concept during development. HUD used as Primary Flight Display.

11. Aircrew Fatigue Countermeasures.
    S. MCCAULEY, USAF/ Scott Air Force Base, US.
    Circadian Rythms and Jetlag Problems.

12. Aircrew Eye/ Respiratory Protection (AERP) Testing. A MAC Airlift Perspective.
    J. SOUSA, USAF/ MAC, US.
    Description of a selected mask fit for air transport crews. Problems encountered during tests.

SESSION III. Specific Technologies.

13. Evaluation of a New Fuel with Higher Energy Density.
    P. E. DESMIER (ORAE), R. R. HASTINGS (NDHQ), CA.
    Selection is in progress for a fuel which would improve the range of tank capacity limited aircraft.

14. The Powerplant Options for a Future Large Aircraft.
    D. G. SPENCER, British Aerospace, R. S. CLOUGH, Rolls Royce, UK.
    A cooperation between airframe and engine manufacturers to optimize the combination for a tactical airlifter. 3 projects compared.

15. Improving Military Transport Aircraft through Highly-Integrated Engine-Wing Design.
    A. LARDELLIER, SNECMA, FR.
    Very high by-pass ratio engines are fit for tactical transports (high T.O. thrust, low SFC). Among them, the Author advocates for a Ducted Rear Contrafan for additional advantages: easy mounting and maintainance, low radar cross-section.

16. The Development of very Thick Multi-Foil Wings for High Speed, Power Lift Transport Aircraft Application.
    J. E. FARBRIDGE, Boeing/ De Havilland, CA.
    An advanced study to show the advantages of a novel wing-flaps configuration.

17. Application of Advanced Technologies to Future Military Transports.
    R. L. CLARK, USAF/ Wright-Patterson AFB, R. H. LANGE, GA ,R. D. WAGNER, NASA Langley, US.
    A parametric study with emphasis on Hybrid Laminar Flow Control. Several resulting projects are described.

18. The C-130 Rear Vision Device.
    M. JULICHER,USAF/ MAC, US.
    In addition to the device, a description of a defensive tactics that transport crews can use against air-to-air attacks from the rear.

19. Technology and Design Considerations for an Advanced Theater Transport.
    R. V. WIBLE, USAF/ Wright Patterson AFB, US.
    A study to optimize an ATT, stressing on STOL/VSTOL comparison, payload versus a/c size and survivability.

SESSION IV. Current and New Programmes.

20. Application of Civil Air Transport Technology to Future Military Airlift.
    J. SPINTZYK, Dornier, GE.
    In the last twenty years, many civil programmes for commuter airplanes were developed. Their technical progresses could benefit a modern medium airlifter.

21. Problems in Converting Civil Aircraft to the Military Tanker Role.
R. J. KILFORD, AAEE, UK.
Definition of needs and criteria used for the conversion of two civil airplanes: VC-10 and L-1011. Problems encountered and experience gained for a future tanker programme.

22. C-160 Transall Life-Time Extension.
H. GRIEM, G. GOLDHAMMER, H-J SCHUBERT, MBB, GE.
A comprehensive rejuvenation programme of the Luftwaffe (structure, systems, cockpit) to extend the Transall life by 20 years.

23. The High Technology Test Bed - A Research Programme for Technology Development.
C. B. PAYNE, Lockheed, US.
A highly modified C-130 for experimental tests developed with equipment Suppliers. Main objective: the STOL performance, through economical solutions that could be fitted to the production aircraft.

24. The C-17: Modern Airlift Requirements and Capabilities.
L. R. TAVERNETTI, Douglas aircraft Company, US.
A description of the C-17 system. Cargohold size, range, rough terrain capability, modern cockpit and controls, freight handling, survivability and maintainability.

25. Future International Military Airlifter (FIMA) and European Future Large Aircraft Group (EUROFLAG).-Progress in Meeting Military Airlift and Future Large Aircraft (FLA) Requirements for the 21st Century.
Common EUROFLAG paper presented by D. K. EMPSON, British Aerospace, UK.
Six European Countries compare their needs. Through trade-offs they will converge toward one progamme for which several configurations are being assessed.

26. Cancelled.

27. V-22 Operational Capabilities.
R. B. TAYLOR, Boeing Helicopters, US.
(No paper available). The lecture was a description of the Tilt-Rotor aircraft and gave a status of the development programme.

28. Military Applications of EUROFAR.
J. GAREN, Aerospatiale Helicopters, FR.
(No specific paper available, but a paper presented in a seminar on "Vertical Lift Aircaft Design", San Francisco, Ca, January 1990, was handed.)
A brief description of the civil EUROFAR Tilt-rotor aircraft project, with potential military developments.

29. Tactical Support EH-101.
J. C. FIELDING, Westland Helicopters, UK.
This helicopter programme claims to fit four categories of customers: Army, Navy, civil and utility users, with different versions. Military versions are described, stressing on advanced features: rotor and blades, powerplant, structure.

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14. Abstract

Although military transport aircraft and helicopters will continue to be of increasing importance in future military operations, military transport aircraft technology has not received the same level of attention that has been directed, for example, to combat aircraft. In-service fleets of transport aircraft are also becoming physically old and technically outdated, and are less and less capable of fulfilling the more demanding mission requirements.

It was therefore important and timely to review the area of military airlift and assess: the present and perceived future military roles and requirements; the required developments in technology; the extent to which civil technology applications can enhance capability; technologies for real cost reduction; and to what extent the current and future development programmes in this field embody the new technologies.

To accomplish this review and assessment, the Flight Mechanics Panel sponsored a Symposium on Progress in Military Airlift, held in Lisbon, Portugal from 28th to 31st May 1990.

The Symposium included sessions on operational experience and requirements; cockpit design and aircrew performance; specific technologies such as fuel, powerplant and aerodynamic design; and a review of current and new programmes.

This Technical Evaluation Report evaluates the presentations and discussions in each session, draws relevant conclusions, and makes recommendations for future activities in this area.

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